Space Weather Technical Forecast

Issued on Monday, 07 March 2022 at 01:05 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Slight chance of G1/Minor Geomagnetic Storm initially. Daily Chance of R1 Minor Radio Blackouts throughout. Possibly a weak CME arriving on 10th March.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Low over the period, with occasional C-class flares observed at GOES 16. These flares peaked with a C2.6 flare at 06/0237UTC from AR2962 in the northeast quadrant.

There are currently four numbered sunspots on the visible disc. AR2960 is the largest and most complex region on the disc, and has recently developed into a beta-gamma configuration. Otherwise, this region appears to be stable for now. AR2957 has shown growth in its leading spots and areal extent, but remains a Dai/Beta-Gamma configuration. AR2962 and AR2961 are both small and stable. AR2958 has now faded, but was responsible for the M2.0 X-ray flare on 02 March and the possible CME in the forecast during the upcoming UTC day of Monday 07 March (from 0300UTC). Confidence is low. Another CME was analysed, which left the sun around 05/0300UTC, which appeared to head northeastwards. This does appear to have an Earth-bound component, with a provisional arrival time of day 4 (10 March) from 10/0900UTC, although confidence is low due to the uncertainty in its origin. There are numerous filaments on the disc, these will continue to be monitored for any CME potential. No other Earth-directed CMEs were evident in available imagery.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, showed a resurgent negative polarity fast wind regime in the period, possibly a transition between the expected coronal holes CH61 and CH62, or perhaps variation within one such feature. The phi angle was accordingly mostly negative (towards the sun).The solar wind speed has been mostly elevated, but briefly strong, with a peak of 604km/s at 06/0036UTC, gradually reducing to the current slightly elevated levels, near 490km/s. The solar wind density started at average values, before increasing above average around 14ppcc. The phi angle was predominantly negative (towards the Sun). The IMF was highest at the start of the period, peaking at 9nT, with weak values for the remainder of the period. The north-south component of the IMF (Bz) varied between -8nT and +3nT with long periods of negative (southward).The net result of the above solar wind measures was resurgent geomagnetic activity, with G1/Kp5 minor geomagnetic storm observed at 06/0600-0900UTC. Otherwise, mostly Quiet to Active (Kp1-4).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) measured at GOES 16 was at Background levels.

The high energy electron flux (greater than 2 MeV) reached High levels, with a peak value of of 3550pfu at 06/1800UTC.

The corresponding 24-hour integrated electron fluence remained well below the Active (1e8 integrated pfu) threshold initially, with a rapid rise during the past 24 hours, reaching above the

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Active threshold by the end of the period. The 07/0001 UTC observation was 1.17e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Expected to be Low, with further occasional C-class flares and a Chance of M-class flares. There is a bright flux region seen in EUVI 195 imagery, which is expected to rotate onto the visible by day 2 (08 March).

Solar Wind / Geomagnetic Activity: There are otherwise three parts to the geomagnetic forecast: the current coronal hole high speed stream(s) from CH61 and CH62, and also a possible glance from a CME emitted on 02/1739UTC in relation to the M2.0 from AR2958. Finally, a weak CME seen heading northeast on 05/0300UTC as been analysed and is likely to arrive at Earth on day 4 (10 March), although confidence is low.

There remains a Chance of G1/Minor Storm from the current high speed stream early on day 1 (7 March), with this risk further bolstered as a result of the uncertain influence of the M2.0-associated CME. Activity should wane from late on day 2 (7 March), becoming most reliably Quiet from day 3 (8 March), but with the caveat should the CME that is expected to arrive on day 4 (10 March).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels.

The high energy electron flux is expected to reach moderate to high levels throughout the periods, due to slightly elevated winds from geoeffective coronal holes. However, this is dependent on any CME arrivals

The chances of Active fluence is expected to be high during the period, with REFM considered to be under-estimating these likely increases.

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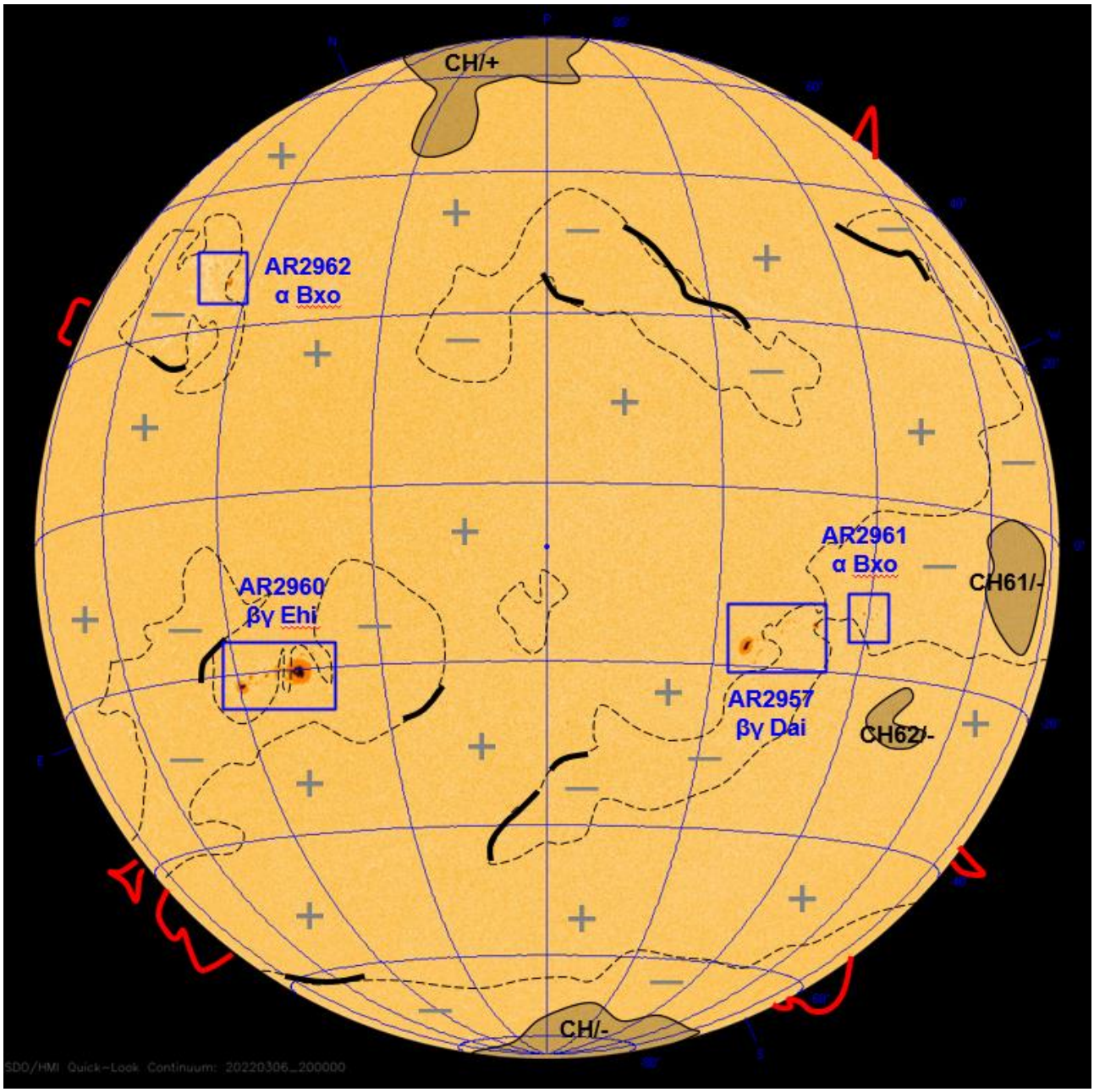
Figure 1. Solar Analysis Valid 06/2000UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Met Office Space Weather Technical Forecast

Geomagnetic Storms:

There are three main aspects of the geomagnetic forecast - firstly the current high speed stream from the combination of CH61 and CH62; and secondly, the possible marginal effects from the 02/1739UTC M2.0 CME that should mainly pass behind the Earth in the track of its orbit.
CH61 and CH62 underwent an unexpected increase in many solar wind measures through the UTC day of Saturday, leading to Minor Storm intervals extending into Sunday 6 March. This increase is expected to begin to wane into day 1 (7 March). Being near the vernal equinox, these negative coronal hole features should make further G1/Minor geomagnetic storms possible, although the prospects of this should fall on day 1 (7 March).

Modelling of the 02/1739UTC M2.0 CME revealed some MOSWOC Enlil ensemble members with 'hits' on or after 06/1200UTC, however closer inspection of their perturbations suggests that these are not favoured scenarios (e.g. excessively wide CME cone angles - compared to observed imagery) Enlil suggests the most likely arrival time is 07/0300UTC. Any impacts from a glancing blow from this CME are expected to be relatively weak, though this is included in the 20% probability of a G1 minor geomagnetic storm on day 1 (7 March).

Finally, a CME which left the sun around 05/0300UTC from the northeast quadrant, although exact origin is still unknown. This was analysed and appears to have an Earth-bound component, which may arrive at Earth on day 4 (10 March) from 0900UTC. This has been given only a 20% attribution given the uncertainty and low confidence.

There remains a slight chance of a G1 geomagnetic storm early on day 1 (7 March). The most reliably Quiet conditions should then occur on days 2 and 3 (8-9 March). The risk increases slightly on day 4 (10 March) should the CME arrive as forecast, albeit a fairly weak feature.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	20	5	10	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
03/0601UTC	Partial	AR2958	N05E39	270km/s	07/0300UTC	Low confidence with unusually wide range for possible arrival time.
06/0650UTC	Partial	Ex2955	N18W75	282km/s	10/2100UTC	Low confidence due to

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						difficulties analysing CME.

Figure 2: BGS Kp observed

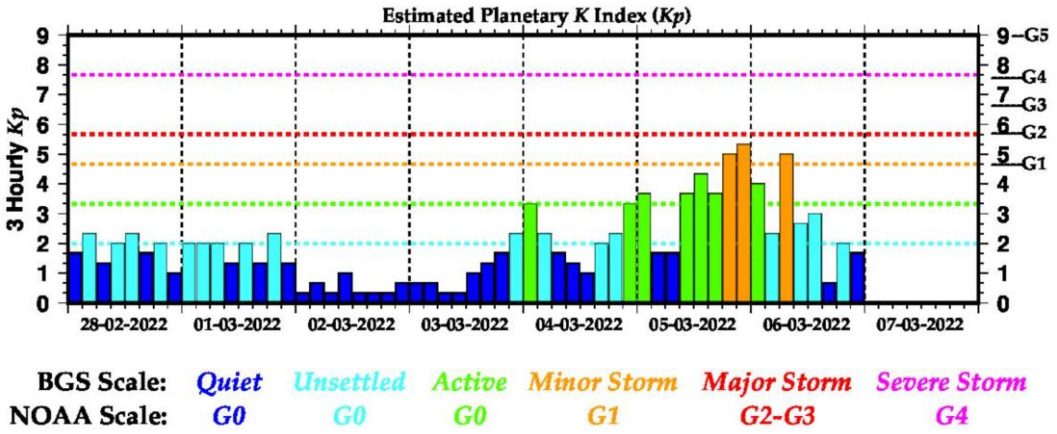

Figure 3: ENLIL (Top) showing potential Earth-directed CME on 10th March, but confidence is low. Large spread in ensembles (Bottom) shows the uncertainty in arrival time at Earth.

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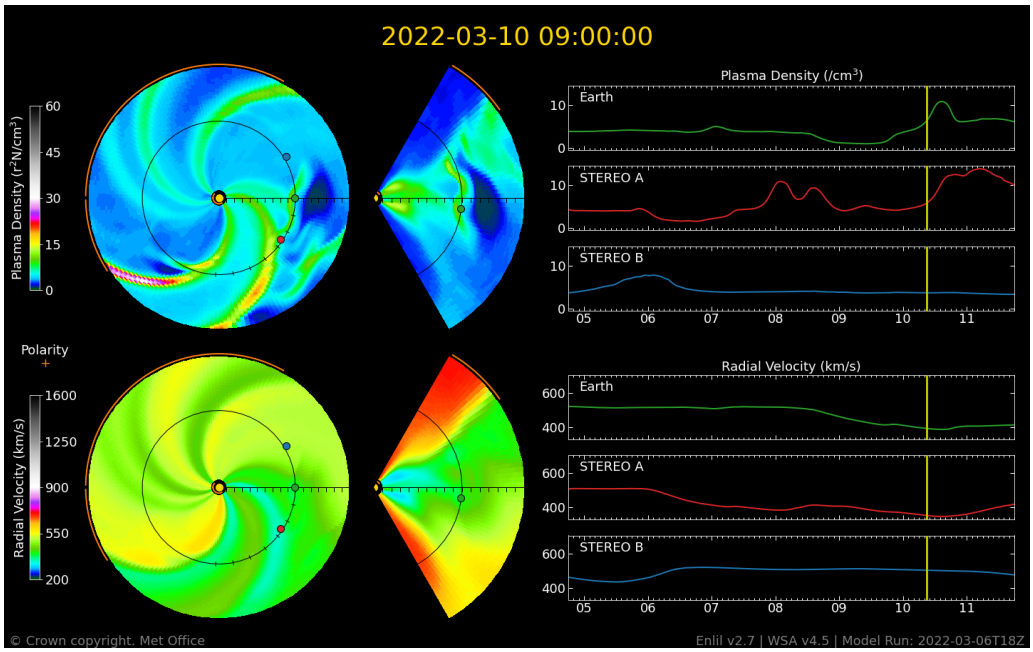

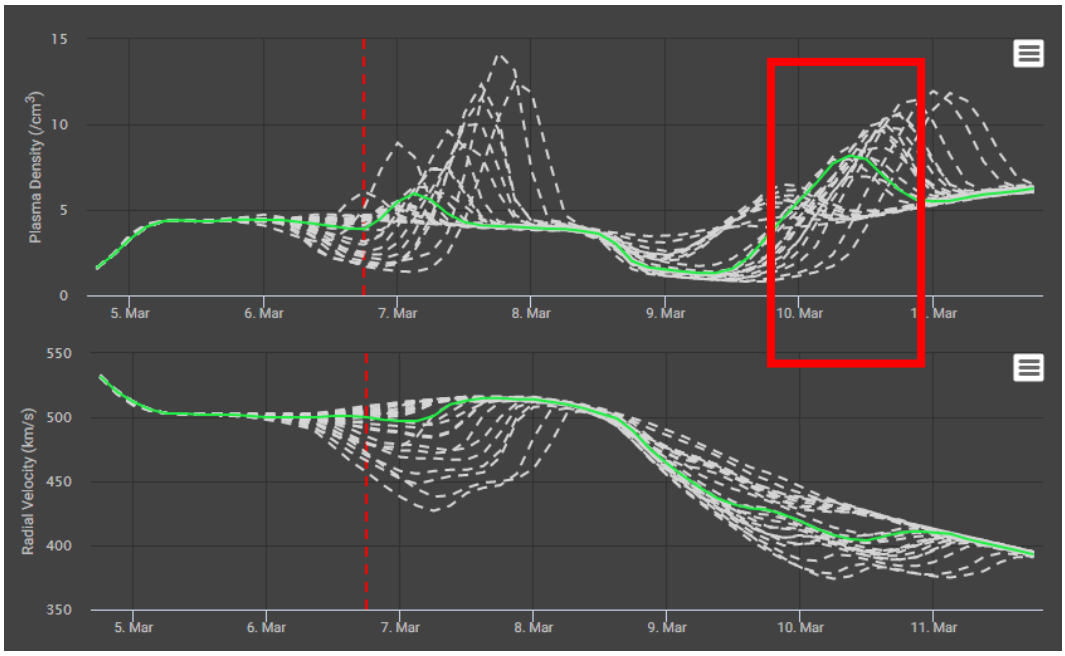

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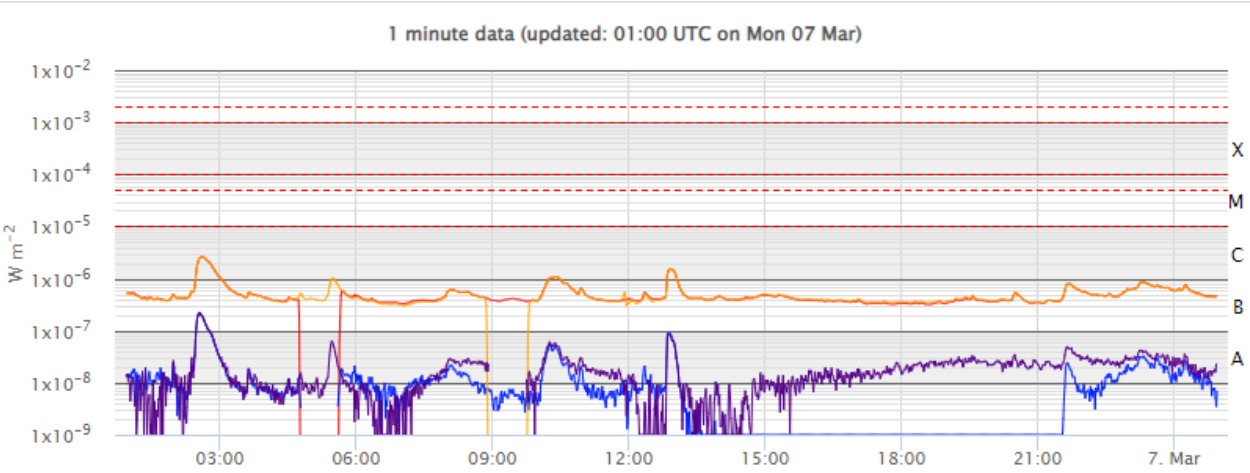
Radio Blackouts - X-Ray Flares:
Barring significant development, the contribution to X-ray flare risk from the current crop of front-sided sunspots is expected to remain largely unchanged in the four-day period, with no new returning regions, although there is now starting to be hints of bright flux around two days away in the northeast (on STEREO A EUVI near 120E).
AR2960 in the southeast appears to be the most active of the current sunspot groups, although perhaps not to the degree that a growing trend in an Ehi/Beta-gamma may suggest. Largely as a result of this region's contributions, the daily risk of C-class flares is rated at 80-90% throughout, with M-class now 25%, increased slightly due to AR2957's stature.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	25	25	25	25
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 4: GOES-16 X-Ray flares



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 is currently at Background levels. The slightly increasing trend in the probabilities is the result of the centre-disc sunspots' nominal potential to produce S1+ events should they flare as they continue westward into slightly more geo-effective positions.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

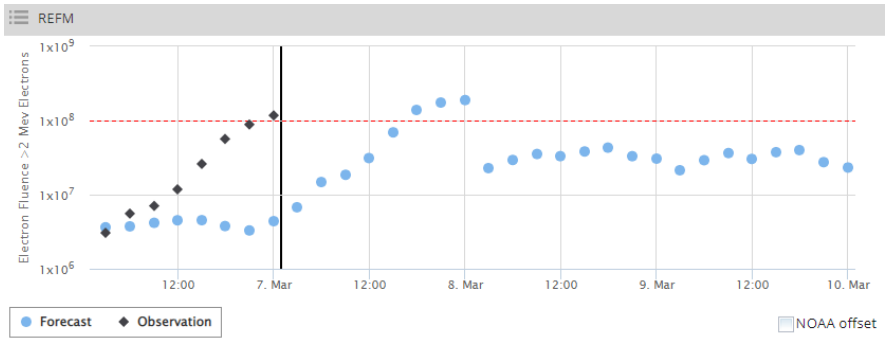
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) has been at Moderate to High levels during the past 24 hours, exceeding the Active threshold during its diurnal cycle. Notwithstanding any possible CME influences. The 1000pfu High threshold is expected to be breached near the diurnal maximum.

This, in turn, should result in an increase in fluence levels, with REFM considered to be underestimating the possibility of the 1e8 integrated electron fluence Active level being reached, even as soon as day 1 (07 March).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	80	70	60	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: Observed electron fluence – reaching the Active >2MeV threshold – above the REFM forecast.



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